Guidelines for Applying IEC Standards to Electrical Distribution Equipment

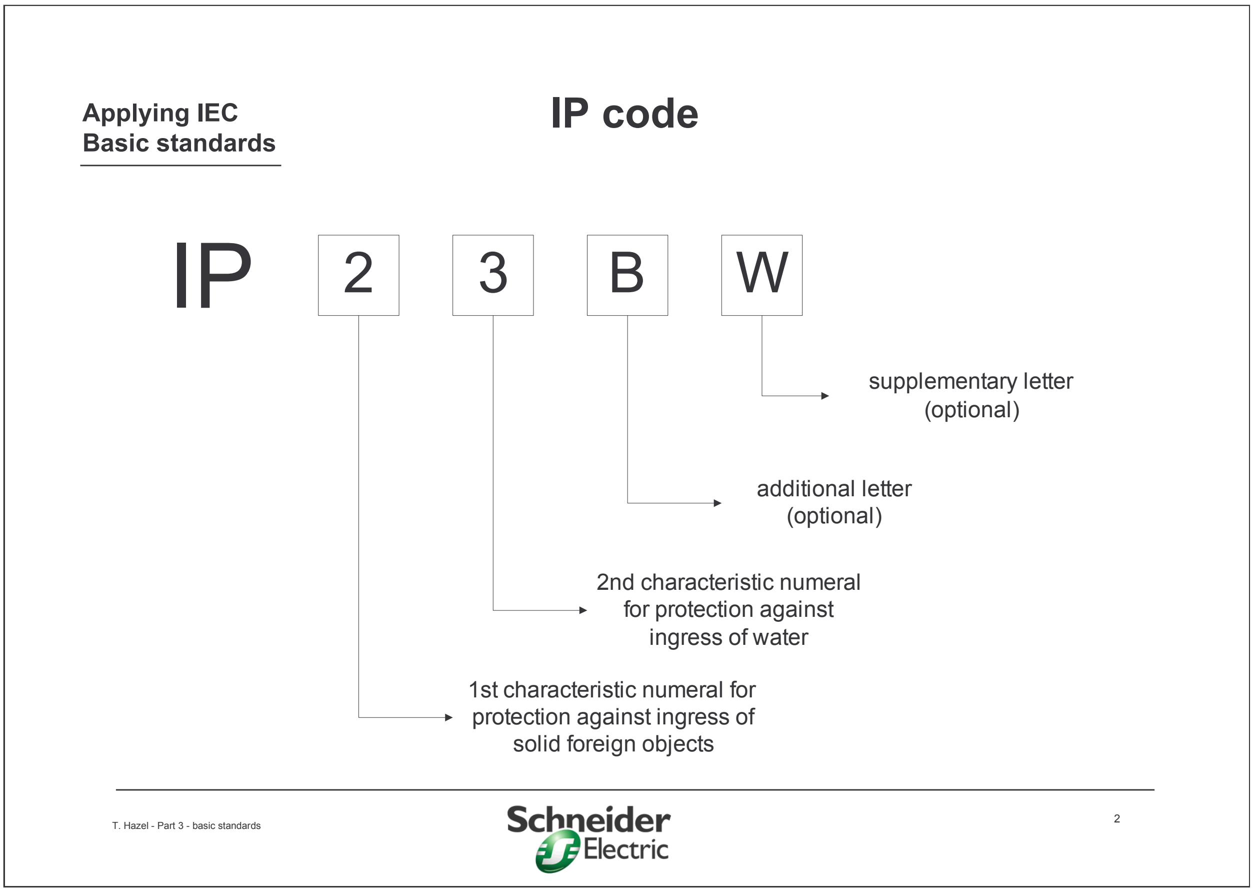
Part 3

Basic IEC standards

basic IEC standards

As discussed in the introduction basic IEC standards are general and deal with topics used in several other IEC standards. Two examples of basic standards are discussed. One defines protection indexes (IP) of envelopes, and the other nominal system voltages. Both of these standards are used in many product standards and therefore it is necessary to be familiar with them in order to apply them correctly.

Another important set of basic standards is IEC61000 Electromagnetic compatibility (EMC). This set of standards contains many parts, and many product standards refer to them.



Applying IEC Basic standards

IP code

IP 2 3 B W

supplementary letter (optional)

additional letter (optional)

2nd characteristic numeral for protection against ingress of water

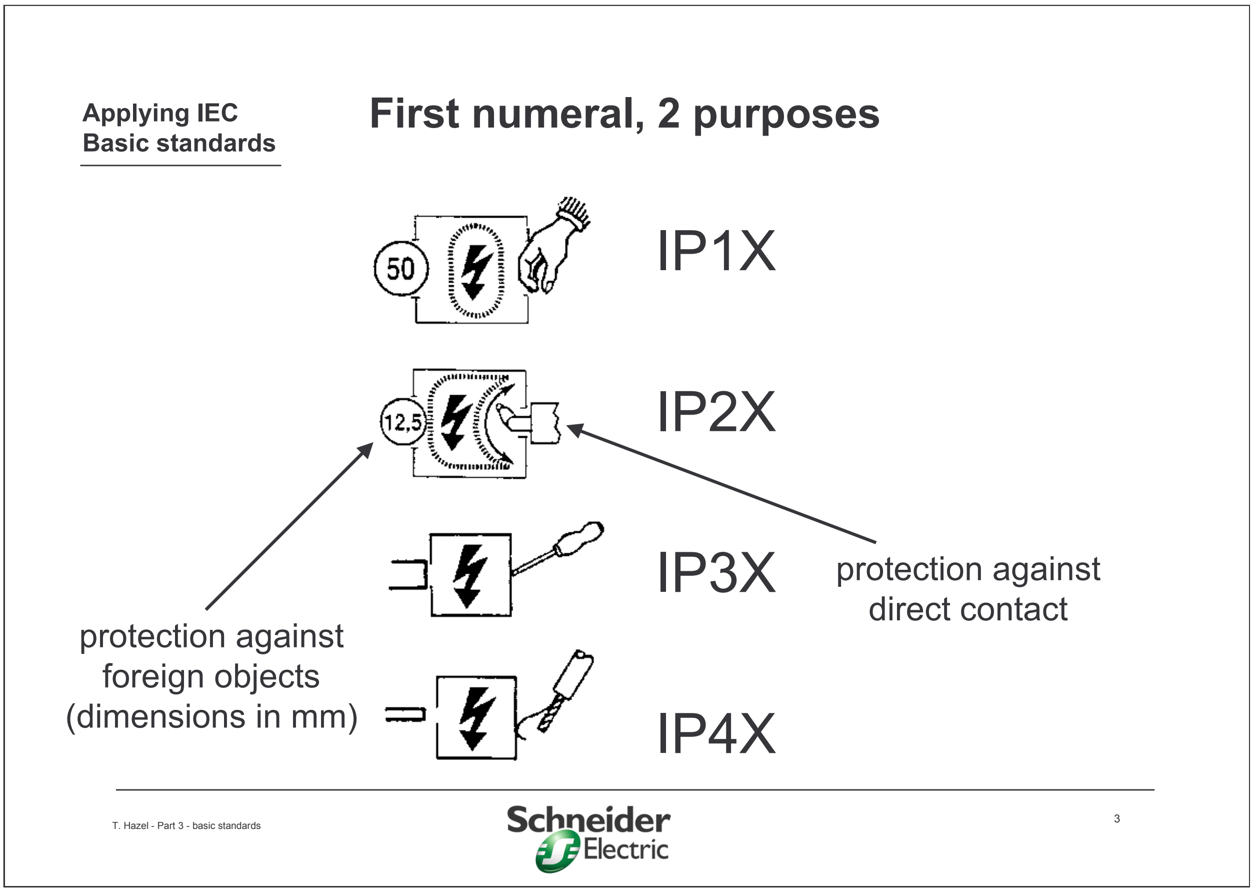
1st characteristic numeral for protection against ingress of solid foreign objects

the IEC protection code (IP)

The IP codes are used to define protection against the ingress of solid foreign objects and water with harmful effects. Since the IP code is used for all equipment, annex B of the IEC standard gives instructions to technical committees for applying IP codes. The protection against the ingress of solid foreign objects is also used as a means of specifying protection against accidental contact with live parts and therefore serves 2 different but related purposes.

interpreting the IP code

The IP code defined in the second edition of *IEC60529 Degrees of protection provided by enclosures (IP code)* consists of 2 numerals and 2 optional extra letters. The first numeral 0, 1,...6, or X defines the protection against ingress of solid foreign objets and against access to hazardous parts. The second numeral 0, 1,...8, or X defines the protection against the ingress of water.



First numeral, 2 purposes

IP1X

IP2X

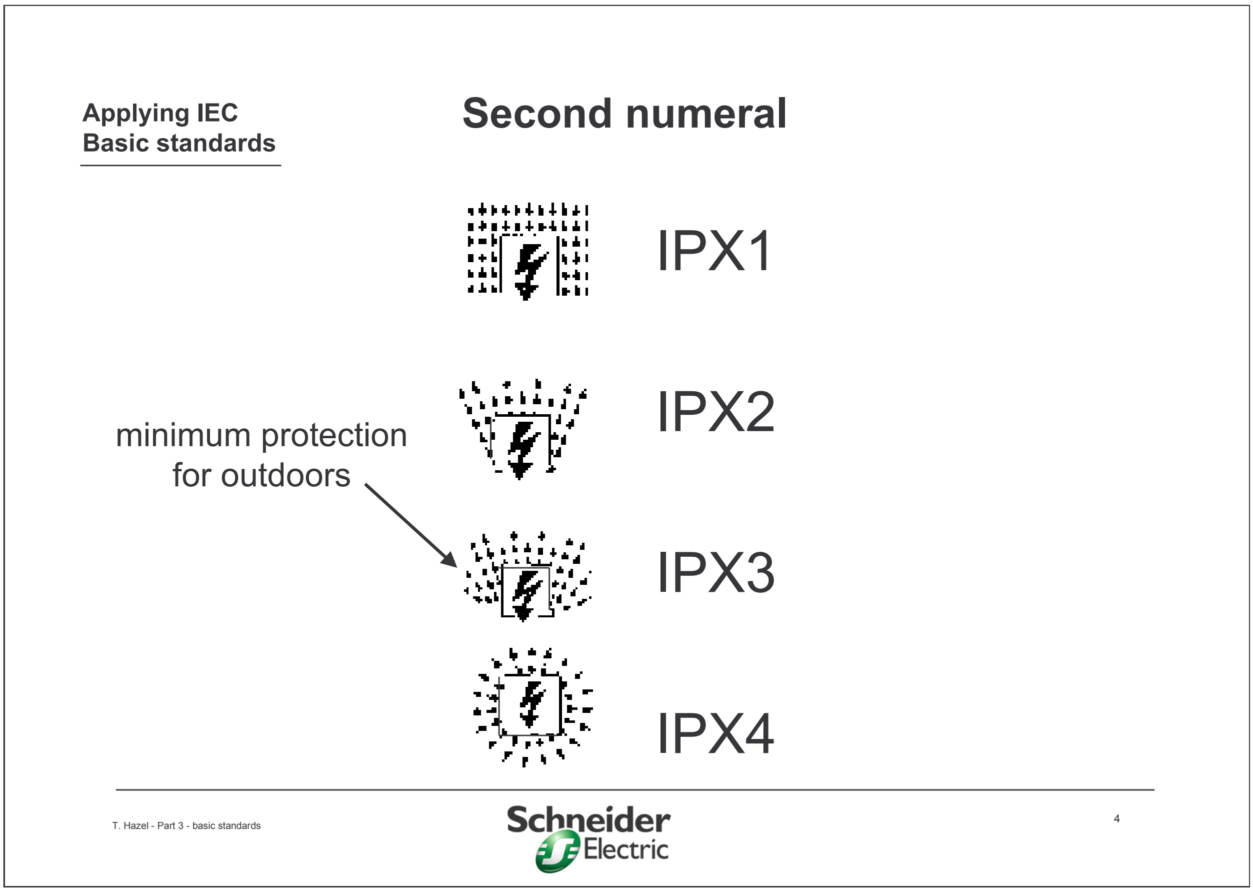
IP3X

IP4X

protection against
foreign objects
(dimensions in mm)

protection against
direct contact

The higher the number the more stringent the protection requirement. The standard defines the protection corresponding to each number and the method of testing for compliance. The first number serves 2 purposes and therefore it has 2 definitions and 2 test methods. For a detailed description of the meaning of each numeral and letter please refer to pages 255, 257, 259 of IEC60947-1 in the appendix of this part of the tutorial.



Applying IEC
Basic standards

Second numeral

IPX1

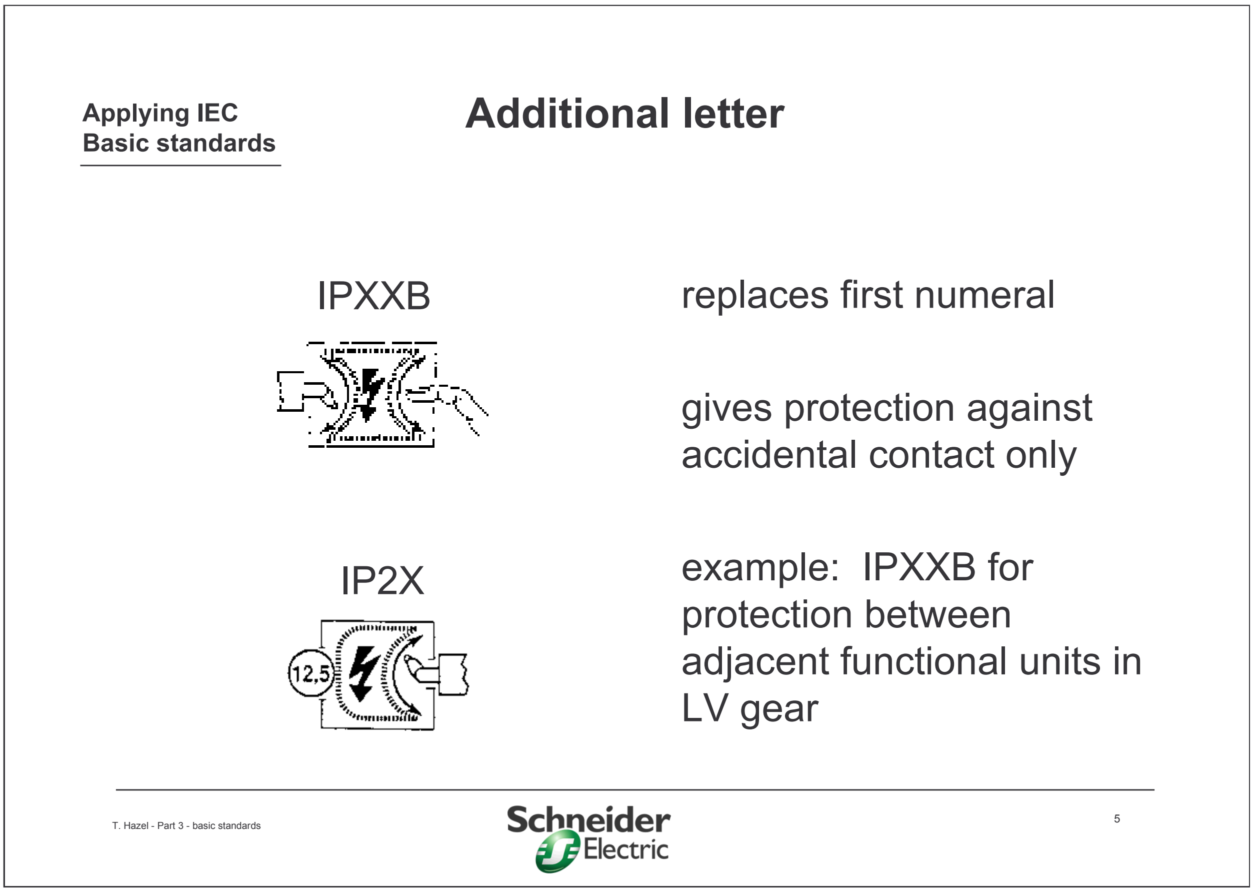
IPX2

minimum protection
for outdoors

IPX3

IPX4

Where there is no requirement for protection against either solid objects or water, the letter ***X*** is used instead of a numeral. An example of this is sub-clause 5.13.2 of *IEC60694 Common specifications for high-voltage switchgear and controlgear* which defines the second numeral as being ***X*** since no protection against ingress of water is specified. This is understandable for high-voltage indoor equipment which is normally installed in electrical rooms having controlled access. Specifying protection against the ingress of water should be done only if there is a real danger of much water falling on the equipment. The test requirement for numeral 1 calls for at least 10mm of water dripping on the enclosure during a 10 minute period. This is much more than just a bit of condensation.



Applying IEC Basic standards

Additional letter

IPXXB

replaces first numeral

gives protection against accidental contact only

IP2X

example: IPXXB for protection between adjacent functional units in LV gear

optional letters

Sub-clause 7 of IEC60529 allows the use of an additional letter A, B, C, or D to indicate protection of persons against access to hazardous parts. This is used instead of the first numeral when the only concern is protection against access to hazardous parts. An example of this is sub-clause 7.7 *IEC60439 Low-voltage switchgear and controlgear assemblies* which specifies the protection against contact with hazardous parts belonging to adjacent functional units as being at least IPXXB.

Applying IEC
Basic standards

Example of IP00

IP00 transformer for installation in a bay.

examples of IP codes

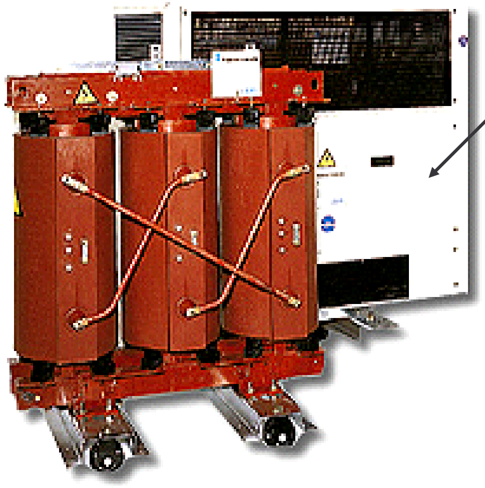
IP00

This code means that there is no protection at all. An typical example is a dry-type transformer without any enclosure. The transformer would be installed indoors in a bay having a door in order to prevent accidental contact with live parts.

If this IP00 transformer is installed in a housing, it is necessary to specify the protection index of the housing as shown on the next page. There can be confusion regarding protection indices when electrical equipment is installed in other equipment. A clear reference to the equipment concerned by the IP code should be given. It may also be necessary to specify under what conditions the IP code is valid. For example, a protection relay may have a protection index of IP 31 when installed in the door of a cubicle, but only IP20 if installed on an open rack. The IP31 is rating is valid for the front face of the relay (the only part exposed when the cubicle door is shut) whereas the IP20 refers to the relay terminal strips which are accessible when the cubicle door is open. One solution is to specify IP31 with cubicle doors closed, and IP20 with cubicle doors open.

Applying IEC
Basic standards

IP00 and IP20

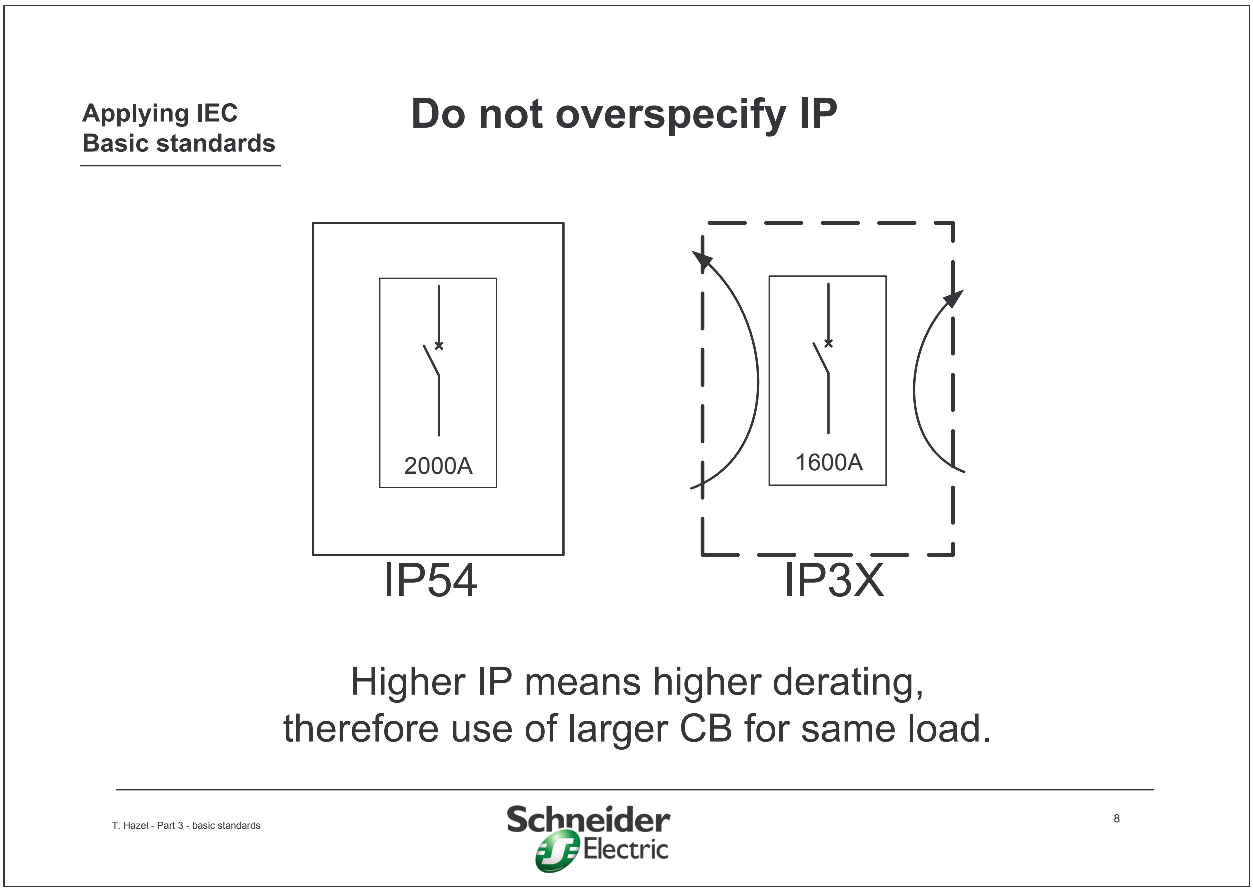


IP00 transformer
in IP20 housing

IP2X
This is the minimum IP code necessary to prevent accidental contact with live parts. All equipment should be specified with a code of at least IP2X except for outdoor equipment installed above ground level or transformers as mentioned above. Where a IP code less than IP2X is used, additional means of protection against accidental contact with live parts must be provided.

IP3X
This is a typical IP code for high-voltage and low-voltage switchgear and controlgear located in electrical rooms. When low-voltage switchgear is located near process equipment a higher value such as IP54 should be considered.

IP53
This is the minimum IP code that should be used for equipment installed outdoors. IP54 would be a better choice since the second numeral 4 means protection against water coming from all directions whereas the numeral 3 means protection against water coming from an angle of 60°.



Applying IEC
Basic standards

Do not overspecify IP

Higher IP means higher derating,
therefore use of larger CB for same load.

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Schneider Electric

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recommendations for the choice of IP codes

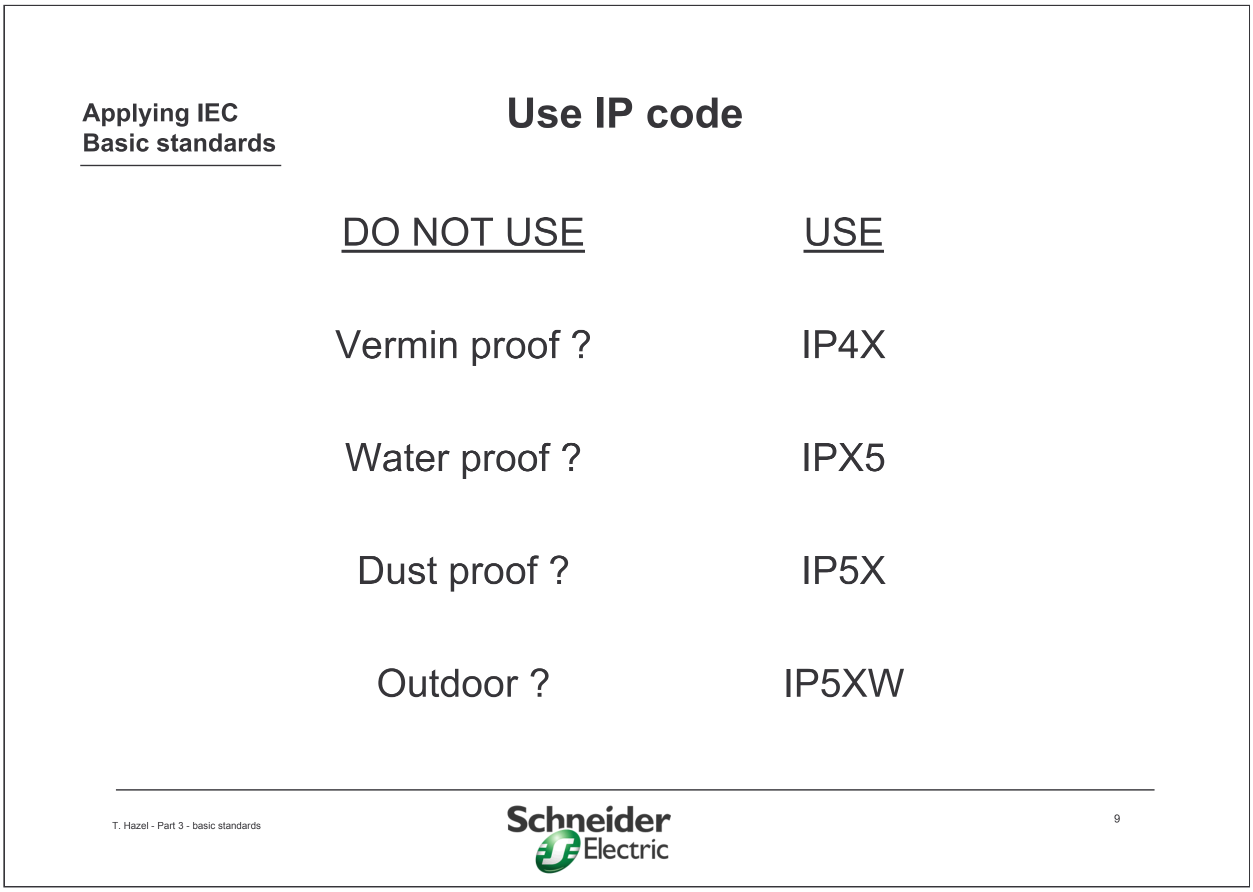
The following points should be considered when specifying IP codes:

Do not overspecify.

A higher number means a more stringent protection requirement and brings with it the disadvantage of less ventilation leading to the possible derating of components. Use the lowest IP rating which meets the application requirements. Where possible use the values recommended in the IEC product standards.

Do not specify protection against ingress of water unless necessary.

High-voltage switchgear and controlgear designed for withstanding the effects of internal arcs often have flaps on the top to let hot gasses exit the gear. The flaps give little or no protection against the ingress of water. Specifying a value other than ***0*** or ***X*** can require a special adaptation to the standard switchboard design which in most cases is not necessary.



Applying IEC
Basic standards

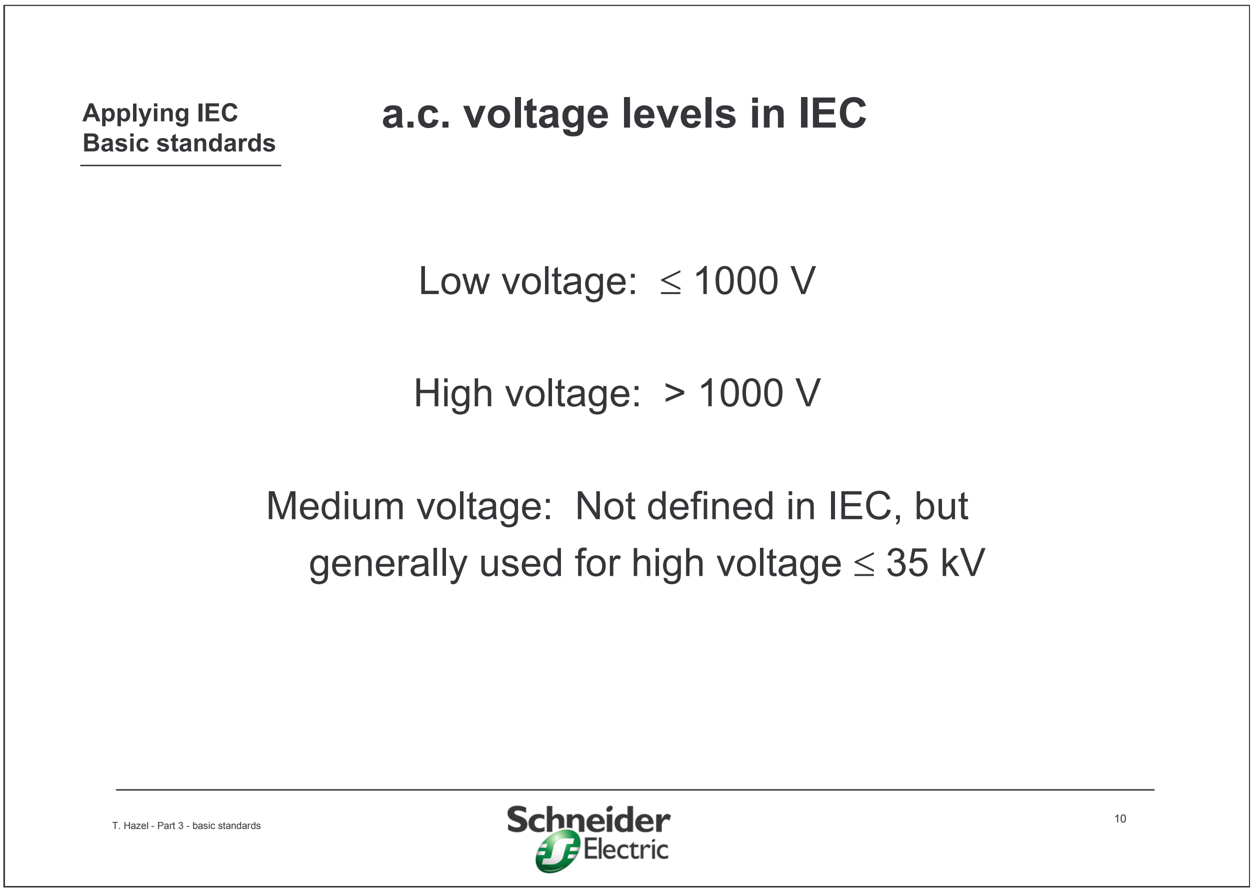
Use IP code

DO NOT USE	USE
Vermin proof ?	IP4X
Water proof ?	IPX5
Dust proof ?	IP5X
Outdoor ?	IP5XW

Be sure to use an IP code.

Terms such as *vermin proof*, *dust proof*, and *water proof* are subject to discussion and are not able to be demonstrated by testing. All IP values however, have test specifications.

Make sure that an IP code is specified for each item of equipment since it is an important criterion in the product definition. Changing the IP to a higher value can have a significant impact on the cost of the equipment.



a.c. voltage levels in IEC

Low voltage: ≤ 1000 V

High voltage: > 1000 V

Medium voltage: Not defined in IEC, but generally used for high voltage ≤ 35 kV

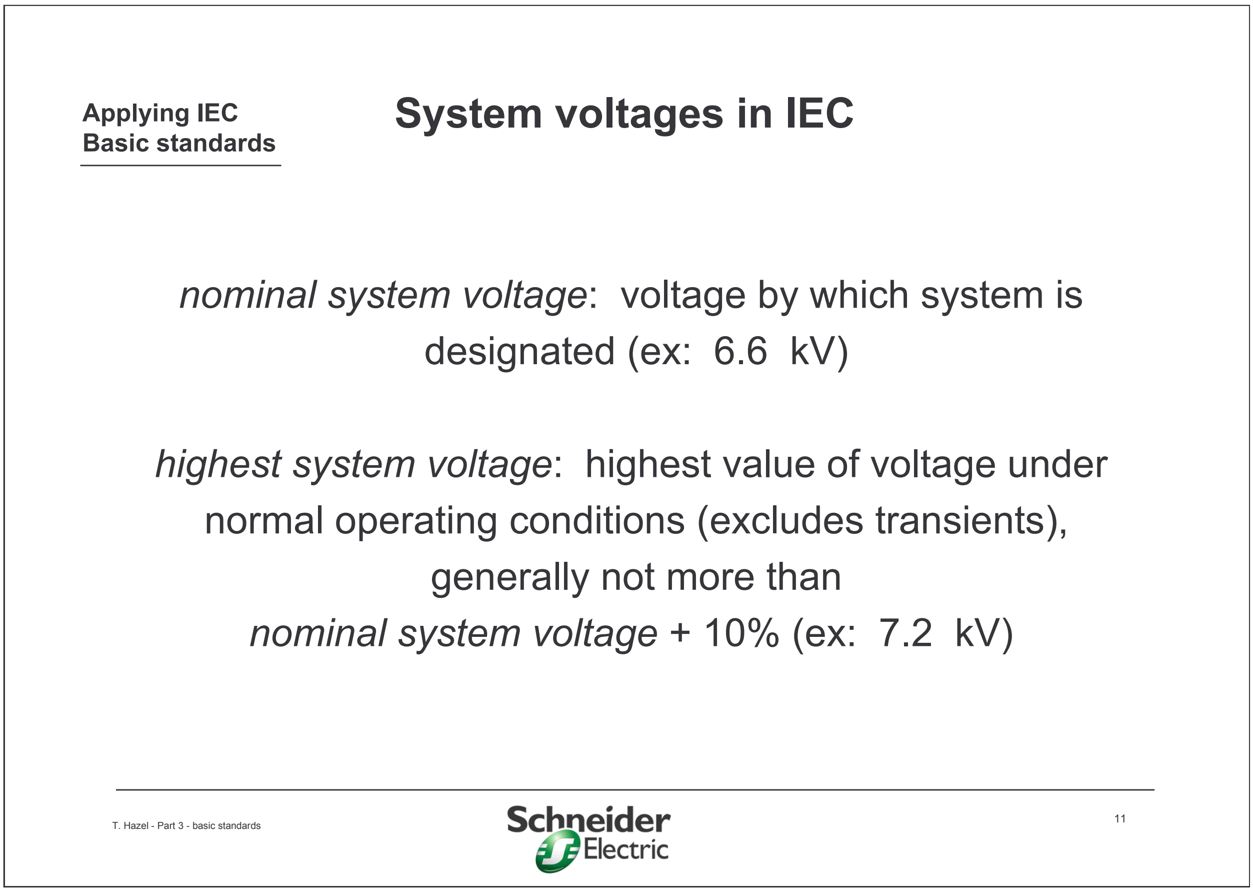
voltage concepts used in IEC standards

voltage levels

The IEC standards distinguish between 2 levels of voltage, *high voltage* where U > 1000V and *low voltage* where U ≤ 1000V.

The term *medium voltage* which is very often used in technical specifications for high voltage up to 35kV is generally not used in IEC standards. An exception is *IEC61000-3-6 Assessment of emission limits for distorting loads in MV and HV power systems*. The distinction is made in this technical report since the emission limits differ in these 2 ranges of high voltage.

When used in this tutorial the term *high voltage* will apply generally to any voltage > 1000V, and the term *medium voltage* will apply to high voltages ≤ 35kV.



Applying IEC
Basic standards

System voltages in IEC

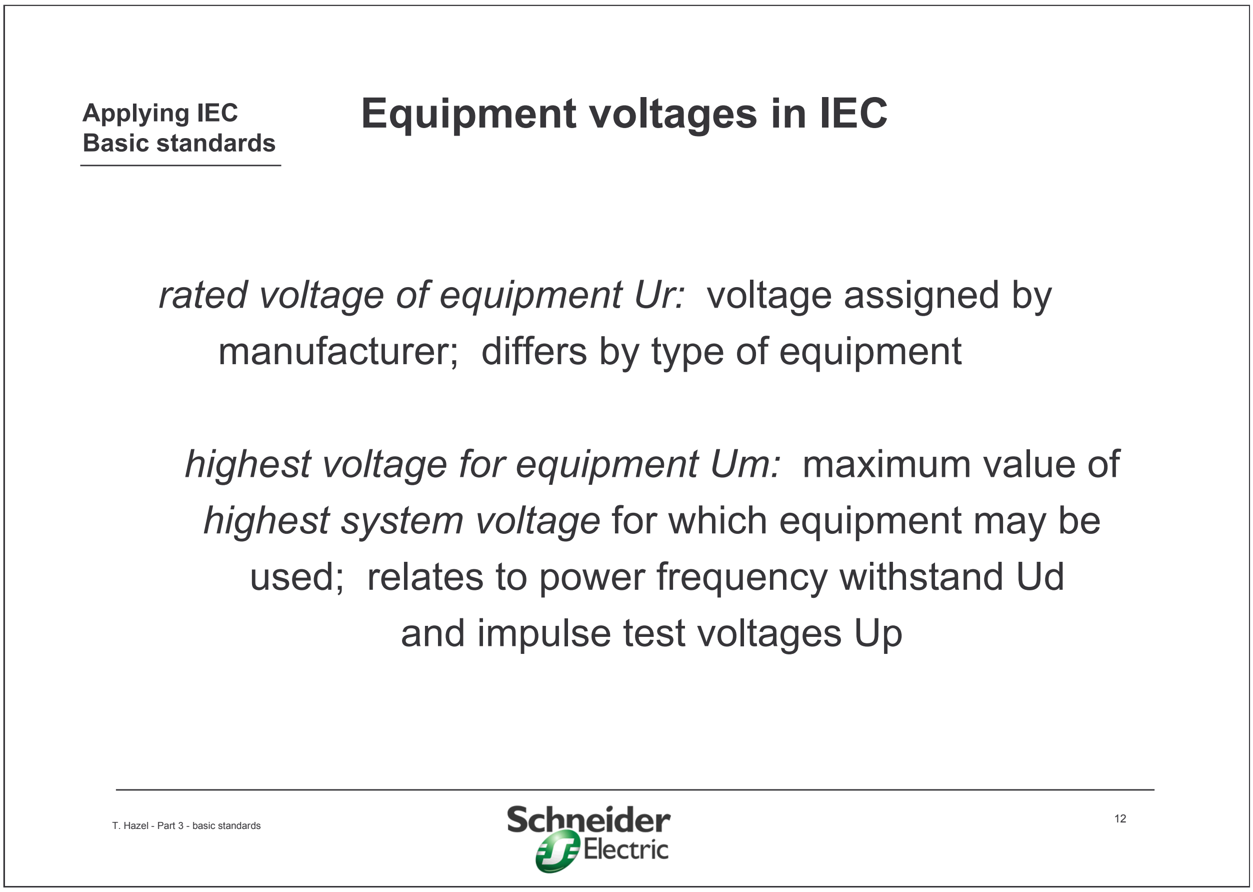
nominal system voltage: voltage by which system is designated (ex: 6.6 kV)

highest system voltage: highest value of voltage under normal operating conditions (excludes transients), generally not more than *nominal system voltage* + 10% (ex: 7.2 kV)

system voltages and equipment voltages

IEC60038 standard voltages amendment 1 defines the *nominal system voltage* as the voltage by which a system is designated. Examples are 6.6kV and 33kV as shown on the single-line diagram in part 2 of the tutorial. The nominal system voltage does not apply to equipment as was the case in the previous edition of this standard. IEC60038 simply defines the *rated voltage of equipment* as being the voltage assigned by the manufacturer for his equipment. The IEC product standards define the meaning of *rated voltage of equipment* for each type of equipment as discussed in section below. In IEC60038 the relation between system voltage and equipment voltage is through the *highest voltage for equipment* where *the highest voltage for equipment* is the maximum value of the *highest system voltage* for which the equipment may be used. This means that a transformer with a rated voltage of 6.6kV having a *highest voltage for equipment* of 7.2kV can be used on a system where the highest system voltage is ≤ 7.2kV.

When standard values of IEC voltages are used there is normally no confusion when discussing nominal system voltages and rated equipment voltages. Care must be taken when values are used which are not standard IEC values. This could lead to supplying equipment with incorrect voltage ratings.



Equipment voltages in IEC

rated voltage of equipment Ur: voltage assigned by manufacturer; differs by type of equipment

highest voltage for equipment Um: maximum value of *highest system voltage* for which equipment may be used; relates to power frequency withstand Ud and impulse test voltages Up

rated voltage for equipment

The term *rated voltage Ur* as applied to equipment differs depending on the type of equipment as illustrated in the following examples.

transformers

For transformers Ur is the voltage assigned to be applied or developed at no-load between the terminals of a winding (IEC60076-1 sub-clause 3.4.3). Since the rated voltage Ur of a transformer has no direct relation with the withstand voltages, the highest voltage for equipment Um must also specified for each transformer winding.

switchgear and controlgear

Sub-clause 4.1 of *IEC60694 Common specifications for high-voltage switchgear and controlgear* defines the *rated voltage Ur* as being the upper limit of the highest voltage of systems for which the switchgear and controlgear is intended. This corresponds to the value of the *highest voltage for equipment* defined in IEC60038 and also the *highest voltage for equipment Um* used for transformers. For each value of Ur the rated short-duration power-frequency withstand voltage Ud (r.m.s. value) and the rated lightning impulse withstand voltage Up (peak value) are given. Quite often there are at least 2 values of Ud and Up for rated voltages commonly used in industrial switchgear. The highest values of Ud and Up are normally specified. The standard values of Um (column 1), Ud (column 2), and Up (column 4) up to 245kV are shown in the appendix to this part of the tutorial.

Commonly used voltages

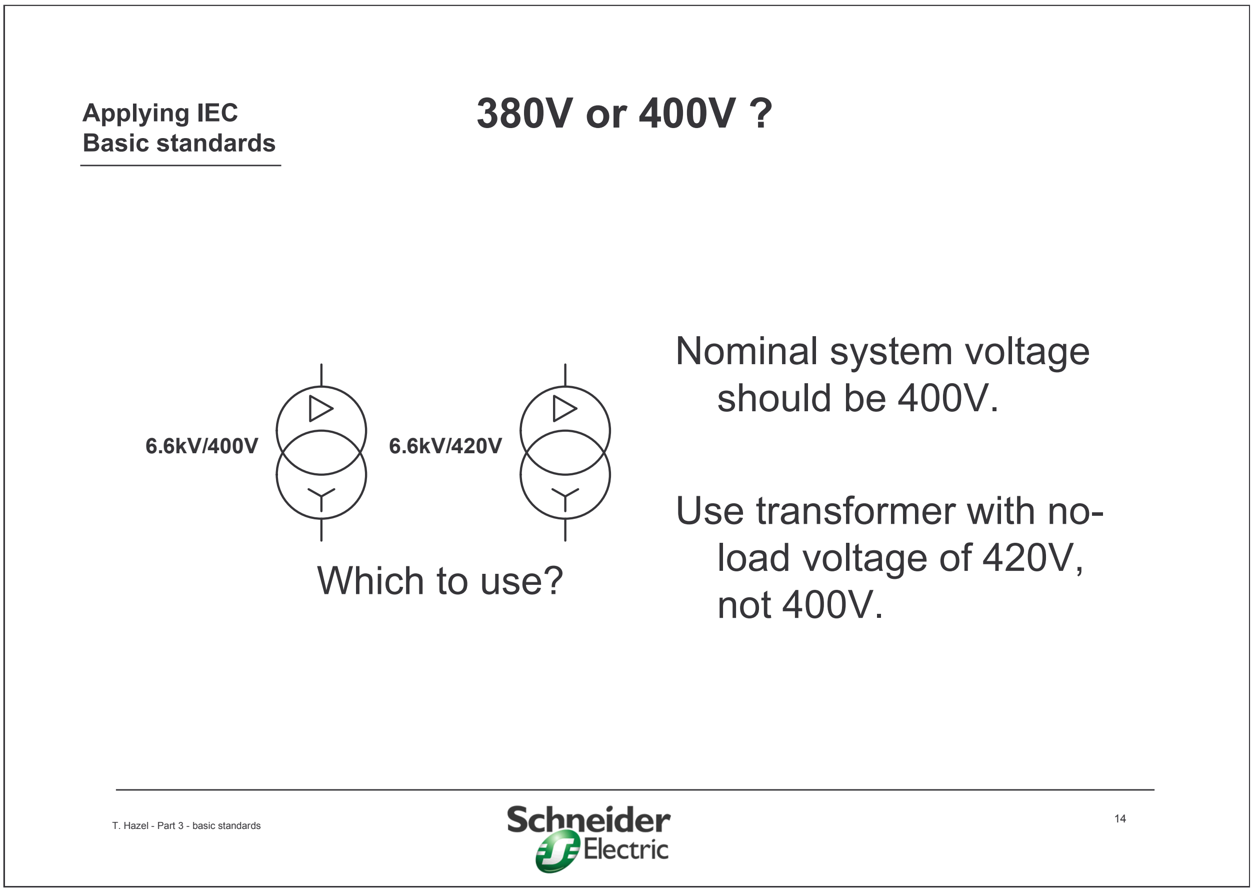
Un	Um	Ud	Up
6.6kV	7.2kV	20kV	60kV
11kV	12kV	28kV	75kV
33kV	36kV	70kV	170kV
110kV	123kV	230kV	550kV

recommended system voltages for high voltage (> 1000V)

IEC60038 has 3 tables giving recommended values of system voltage. Table III which goes up to 35kV corresponds to medium voltage and together with table IV which goes up to 230kV give the voltages which are applicable for industrial applications.

Table III has 2 sets of values called Series I and Series II. The values of Series I of this table are for both 50Hz and 60Hz systems with the exception of systems in North America. They should therefore be used for any new projects outside the North American continent. Series I of table III has 2 groups of nominal system voltages as shown in the following table.

Um	nominal system voltage	nominal system voltage
3.6kV	3.3kV	3kV
7.2kV	6.6kV	6kV
12kV	11kV	10kV
(17.5kV)	--	(15kV)
24kV	22kV	20kV
36kV	33kV	30kV
40.5kV	--	35kV


6.6kV/400V
6.6kV/420V

Applying IEC
Basic standards

380V or 400V ?

Which to use?

Nominal system voltage should be 400V.

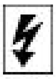
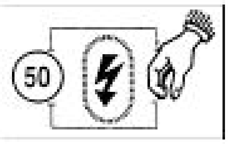
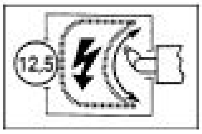
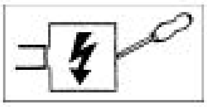
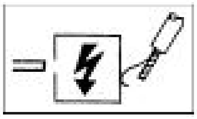
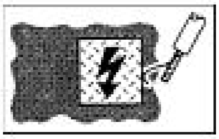
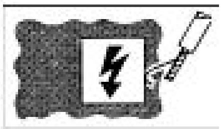
Use transformer with no-load voltage of 420V, not 400V.

400V or 380V?

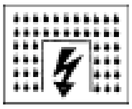
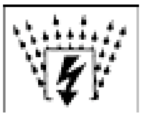
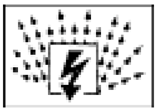
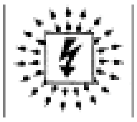
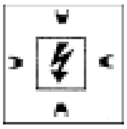
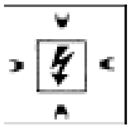
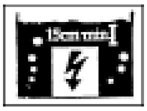
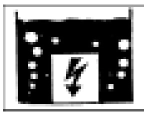
Several years ago it was decided to harmonize the values of voltage used in 50Hz applications. Previously the 2 values were 220/380V and 240/415V, and the new harmonized value was chosen to be 230/400V. All new applications should have a nominal system voltage of 230/400V. This is being applied in most countries but some countries such as Algeria and China still use 220/380V as the nominal system voltage for new low-voltage applications. The value of the nominal system voltage must always be checked with the client in order to ensure that equipment with the correct voltage rating will be ordered. The fact that the no-load voltage of step-down transformers is indicated on single-line diagrams sometimes leads to confusion since a no-load voltage of 400V is used for systems having a nominal voltage of 380V. For a nominal system voltage of 400V, a secondary no-load voltage of 420V is typically used.

After the transition period the tolerance associated with 230/400V should be ±10% and will probably be decreased at a later date. The transition from 380/660V to 400/690V nominal system voltages is being done in parallel with the transition from 220/380V to 230/400V.

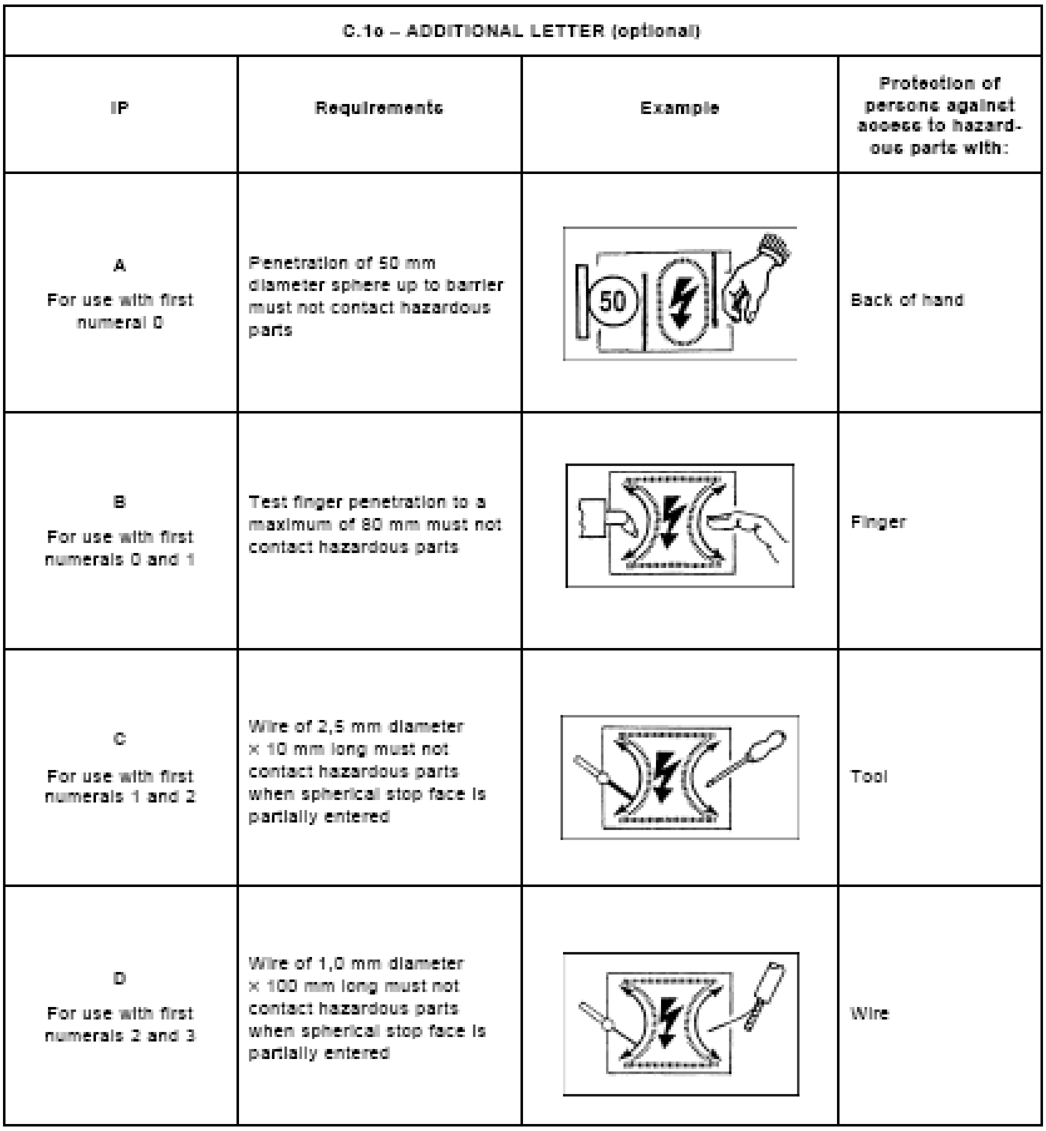
First numeral of IP index

C.1a – FIRST NUMERAL			
Protection against ingress of solid objects			Protection of persons against access to hazardous parts with:
IP	Requirements	Example	
0	No protection		Non-protected
1	Full penetration of 50 mm diameter sphere not allowed. Contact with hazardous parts not permitted		Back of hand
2	Full penetration of 12,5 mm diameter sphere not allowed. The jointed test finger shall have adequate clearance from hazardous parts		Finger
3	The access probe of 2,5 mm diameter shall not penetrate		Tool
4	The access probe of 1,0 mm diameter shall not penetrate		Wire
5	Limited ingress of dust permitted (no harmful deposit)		Wire
6	Totally protected against ingress of dust		Wire

Second numeral of IP index

C.1b – SECOND NUMERAL			
Protection against harmful ingress of water			Protection from water
IP	Prescriptions	Example	
0	No protection		Non-protected
1	Protected against vertically falling drops of water. Limited ingress permitted		Vertically dripping
2	Protected against vertically falling drops of water with enclosure tilted 15° from the vertical. Limited ingress permitted		Dripping up to 15° from the vertical
3	Protected against sprays to 60° from the vertical. Limited ingress permitted		Limited spraying
4	Protected against water splashed from all directions. Limited ingress permitted		Splashing from all directions
5	Protected against jets of water. Limited ingress permitted		Hosing jets from all directions
6	Protected against strong jets of water. Limited ingress permitted		Strong hosing jets from all directions
7	Protected against the effects of immersion between 15 cm and 1 m		Temporary immersion
8	Protected against long periods of immersion under pressure		Continuous immersion

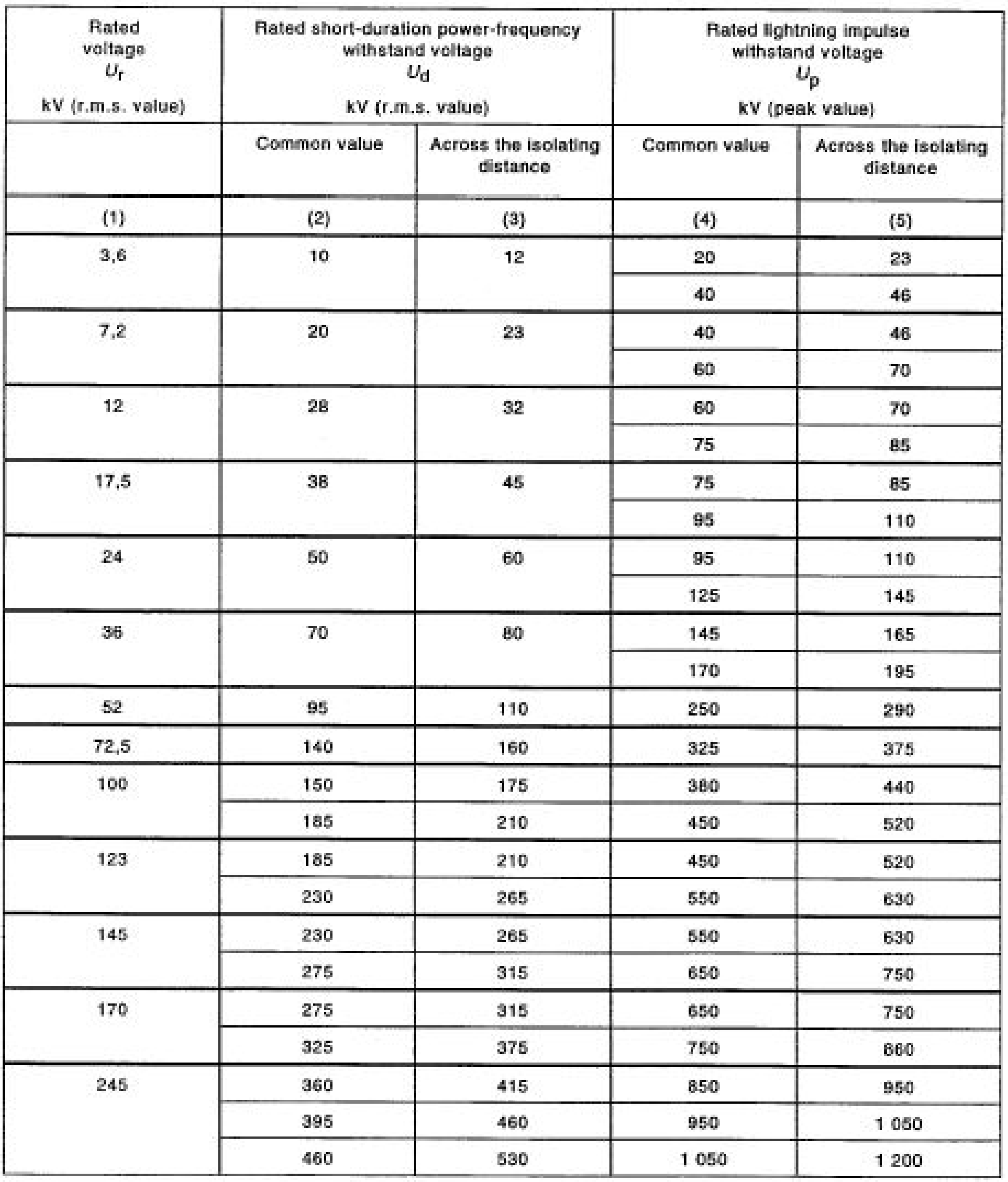
Optional additional letter of IP index



C.1c – ADDITIONAL LETTER (optional)

IP	Requirements	Example	Protection of persons against access to hazardous parts with:
A For use with first numeral 0	Penetration of 50 mm diameter sphere up to barrier must not contact hazardous parts	50	Back of hand
B For use with first numerals 0 and 1	Test finger penetration to a maximum of 80 mm must not contact hazardous parts		Finger
C For use with first numerals 1 and 2	Wire of 2,5 mm diameter × 10 mm long must not contact hazardous parts when spherical stop face is partially entered		Tool
D For use with first numerals 2 and 3	Wire of 1,0 mm diameter × 100 mm long must not contact hazardous parts when spherical stop face is partially entered		Wire

Rated insulation levels for commonly used IEC voltages



Rated voltage U_r kV (r.m.s. value)	Rated short-duration power-frequency withstand voltage U_d kV (r.m.s. value)		Rated lightning impulse withstand voltage U_p kV (peak value)	
	Common value	Across the isolating distance	Common value	Across the isolating distance
(1)	(2)	(3)	(4)	(5)
3,6	10	12	20	23
			40	46
7,2	20	23	40	46
			60	70
12	28	32	60	70
			75	85
17,5	38	45	75	85
			95	110
24	50	60	95	110
			125	145
36	70	80	145	165
			170	195
52	95	110	250	290
72,5	140	160	325	375
100	150	175	380	440
	185	210	450	520
123	185	210	450	520
	230	265	550	630
145	230	265	550	630
	275	315	650	750
170	275	315	650	750
	325	375	750	860
245	360	415	850	950
	395	460	950	1 050
	460	530	1 050	1 200